

# Treatment of subtrochanteric femoral fracture with long proximal femoral nail antirotation

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**【Abstract】Objective:** Subtrochanteric femoral fractures are severe injuries. Although many treatment methods have been developed, controversy exists regarding the optimal management of these fractures. This study evaluated the clinical outcome of subtrochanteric femoral fractures fixed with long proximal femoral nail antirotation (PFNA-long).

**Methods:** Between October 2006 and February 2008, 25 patients with traumatic subtrochanteric fractures of the femur were treated with PFNA-long. Closed reduction and fixation were performed in 20 cases. In the remaining 5 cases, closed reduction was difficult, so limited open reduction was performed, with bone grafting in 4 cases and circumfer-

ential wiring in 4 cases.

**Results:** The average follow-up time was 16.1 months. All subtrochanteric femoral fractures healed uneventfully except one case of delayed union. The mean union time was 26.2 weeks. Technical difficulties with nail insertion were encountered in 3 cases. No implant failure was observed.

**Conclusion:** PFNA-long is effective in treatment of subtrochanteric femoral fractures, with a high rate of bone union, minor soft tissue damage, early return to functional exercise and few implant-related complications.

**Key words:** Femoral fractures; Fracture fixation, internal; Bone nails

*Chin J Traumatol 2010; 13(1):37-41*

Subtrochanteric femoral fracture is one of severe injuries in clinic. Biomechanical test has confirmed that the subtrochanteric region of the femur is subjected to concentrated high stress and compressive stress in the medial cortex is significantly greater than tensile stress in the lateral cortex.<sup>1,2</sup> The biomechanical characteristics of the area, poor vascularity caused by the predominance of cortical bone, and inadequacy of reduction and internal fixation are responsible for malunion, delayed union and mechanical failure of implants used in the treatment.<sup>2-9</sup>

Because nonoperative treatment requires prolonged bed rest, sometimes leading to serious recumbency-related complications,<sup>2,3</sup> surgical stabilization is generally recommended for subtrochanteric fractures of the femur.<sup>2,3,5,6,10-13</sup> However, mechanical failure rates have been reported to be 5.7% to 20%.<sup>7,12</sup>

In 2004, AO/ASIF developed a novel device—proximal femoral nail antirotation (PFNA) for the treatment of unstable proximal femoral fractures. Favorable outcome and reduced mechanical failure have been achieved with PFNA.<sup>14,15</sup> To our knowledge, however, few reports have been published on the use of long proximal femoral nail antirotation (PFNA-long) to treat subtrochanteric fractures of the femur. The current study was to evaluate the early clinical results of treating subtrochanteric femoral fractures with this new device.

## METHODS

From October 2006 to February 2008, 25 cases of traumatic subtrochanteric fractures of the femur were treated by means of PFNA-long (Synthes GmbH, Oberdorf, Switzerland) at West China Hospital of Sichuan University (Chengdu, China). The participants consisted of 21 males and 4 females, with the range of 20 to 58 years (average, 45.6 years). Subtrochanteric femoral fractures were classified by the Seinsheimer classification.<sup>7</sup> There were 3 cases of type II, 6 type III, 8 type IV, and 8 type V. Most patients had experienced high-energy injuries: 16 were involved in traffic accidents (automobiles or motorcycles) and 9 had falling injury from heights. Associated injuries were recorded (Table 1).

DOI: 10.3760/cma.j.issn.1008-1275.2010.01.007

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Pathological fractures were not included in the study.

**Table 1.** The associated injuries of patients

Injury types	<i>n</i>
Olecranal fracture	1
Mandibular laceration	3
L <sub>5</sub> , medial malleolus fracture (left)	1
Forehead laceration	3
Abdominal injury	1
Head of fibula fracture (left)	1

There were 3 types of PFNA-long with different lengths, including 300 mm, 340 mm and 380 mm. The length of helical blade ranged from 85 mm to 105 mm. The nail had 10° anteversion, 1500 mm bending radius antecurvature, 6° medial-lateral angle for smooth insertion and an anatomically correct fit. The distal diameter of the nail was 10 mm and the centre-collum-diaphysis (CCD) angle was 130°. The distal part of the nail contained 2 oval holes for either dynamic or static locking purposes.

After preoperative measurement and planning, according to a true anteroposterior (AP) radiograph of the fractured hip (if an accurate anatomical reduction had been obtained) or the contralateral hip, the patient was positioned supine on an orthopaedic table. Closed reduction was achieved under fluoroscopic guidance. A rolled sheet was placed to elevate the affected hip by 20°-30°. The affected leg was placed in 10°-15° adduction to facilitate the nail insertion. A lateral skin incision of about 8 cm was made over the lateral side of the thigh and across the center of the trochanteric region. A guide pin was inserted from the trochanteric apex and passed through the fracture site. After the proximal femur was opened with a 17 mm reamer, the appropriate nail was then inserted. The helical blade was inserted using light blows with the hammer. With the tip about 10 mm from the joint surface, the neck blade was locked. Distal locking was achieved using a free-hand technique. All cases were locked statically. Because of the fracture complexity, 5 patients had limited open reduction. Four cases received autologous or artificial bone grafts (MasterGraf, Medtronic Sofamor Danek, Minneapolis, Minnesota, USA), as determined by the surgeon during operation (Figure 1). Circumferential wiring was applied over comminuted subtrochan-

teric fracture fragments in 4 cases (Figure 2).

All patients received antibiotic prophylaxis. Patients were encouraged to do leg exercises postoperatively. The postoperative ambulatory program involved non-weight-bearing and gradual partial activities for 6 to 8 weeks, and then full-weight-bearing activities.

When the patient restored the mobility and full weight bearing without pain or visible radiological consolidation of the fracture, the fracture was considered to be healed. If there was no complete radiological consolidation of the fracture 6 months later, it was classified as a delayed union. If the consolidation exceeded one year, the fracture was classified as a non-union.<sup>16</sup> We recorded the surgical complications, union events and implant-related complications. The clinical outcomes were evaluated according to Sanders scores.<sup>13</sup>



**Figure 1.** A: Traumatic subtrochanteric fracture of the left femur. B: Closed reduction and fixation with PFNA-long. The artificial bone was grafted with a mini-incision. C: The fracture healed without complications.



**Figure 2.** A: Subtrochanteric fracture of the right femur. B: Limited open reduction and internal fixation with PFNA-long, with use of circumferential wiring. C: The fracture healed without implant failure.

## RESULTS

In this study, the mean duration of hospitalization was 21.7 days (range, 15-57 days). The average operating time was 90 minutes (range, 60-155 minutes). The mean intraoperative blood loss was 200 ml (range, 100-400 ml). The average postoperative drainage was

110 ml (range, 100-210 ml). The mean follow-up period was 16.1 months (range, 12-20 months). The average union time for the subtrochanteric fractures of the femur was 26.2 weeks (range, 18-48 weeks). Except for one case of delayed union, all fractures healed uneventfully (Figure 3).



**Figure 3.** A: Subtrochanteric fracture of the left femur. B, C: Closed reduction and internal fixation with long proximal femoral nail antirotation. D: The fracture healed uneventfully.

Technical difficulties were encountered with nail insertion in 3 cases. After meticulous reaming in 0.5 mm steps, up to 2 mm larger than the nail distally, the nail was inserted. In 2 cases, the helical blade was poorly placed, superiorly on the AP radiograph in one case and anteriorly on the lateral radiograph in the other. The fractures healed without femoral head penetration and cut-out of the helical blade.

Some adverse events (complications) were observed. One case developed superficial wound infection, and recovered after the treatment of intravenous antibiotics without surgical intervention. One case had delayed union, with eventual union at postoperative 48 weeks without mechanical failure. Four patients complained of hip pain after exertion. Because of concomitant ipsilateral fracture of the tibial plateau and shaft, knee stiffness was present in one case. According to Sanders scores, the clinical results were excellent in 18 cases, good in 5 and poor in 2. No mechanical failures of the implant occurred, and no femoral head penetration or cut-out of the helical blade was found. During the follow-up, no femoral shaft fractures at the nail tip were observed.

## DISCUSSION

Implants available for use in the subtrochanteric area are either extramedullary or intramedullary. Extramedullary fixation has the potential disadvantages of extensive surgical dissection, longer operative time, more intraoperative blood loss, and insertion difficulty. In addition, mechanical failure of these fixation devices due to the long lever arm and nonunion are relatively common.<sup>9,13,17,18</sup> In subtrochanteric femoral fractures, extramedullary fixation depends on screw fixation of a plate to the lateral cortex, so the mechanical stability of fixation would be problematic.<sup>3,19</sup> Moreover, due to the risk of varus collapse and a low union rate, extramedullary fixation is not recommended for complex fractures.<sup>8,13</sup>

The advantages of intramedullary devices over extramedullary ones are less extensive exposure, fewer biomechanical stresses with medial movement of the lever arm and earlier weight-bearing.<sup>3,5,6,10</sup> Intramedullary devices involve conventional femoral interlocking nails, including the Gamma nail and the proximal femoral nail (PFN).<sup>6,11,17,20,21</sup> If the medial femoral cortex is comminuted, conventional femoral interlocking nails may be biomechanically unstable.<sup>20</sup> Most technical

failures with the Gamma nail are due to a lack of rotational stability of the proximal fragment and/or malpositioning of the neck screw. The major complications associated with Gamma nail fixation, in fracture of the femoral shaft, have been reported to occur in 2% to 11% of cases.<sup>5, 6, 22</sup> In recent years, favorable outcomes with few complications have been achieved in the cases of subtrochanteric fracture treated with the long Gamma nail (LGN).<sup>3, 10-12</sup> In 1997, AO/ASIF developed the PFN to overcome the limitations associated with the Gamma nail. The PFN provides rotational stability to the proximal fragment with two proximal locking hip screws and reduces the incidence of cut-out.<sup>16, 21</sup> The clinical results of PFNA-long in the treatment of subtrochanteric femoral fractures have been encouraging, with no mechanical failures of the implant, although technical difficulties are encountered with the insertion of proximal locking screws.<sup>21</sup>

PFNA improves the biomechanical properties and yields better purchase of the helical blade in the femoral head.<sup>15, 23</sup> The blade has been biomechanically proved to provide increased rotational stability with compaction of cancellous bone around the blade, and better resistance to varus collapse.<sup>14, 23, 24</sup> The benefits of PFNA-long are its minor invasiveness and fewer procedural steps, more convenient use as compared with extramedullary implants and the conventional PFN,<sup>24</sup> early return to functional exercises and the possibility of immediate partial weight-bearing. In this study, although follow-up period was not adequate to obtain long-term outcomes, the results of the PFNA-long fixations were satisfactory.

Some reports in the literature have shown that unsatisfactory reduction of the neck-shaft angle results in the failure of internal fixation in subtrochanteric femoral fractures.<sup>7, 8, 10</sup> If closed reduction is not satisfactory, varus malalignment should not be accepted, and open reduction and circumferential wire fixation should be used.<sup>10, 21, 22</sup> In the present study, limited open reduction and/or fixation with circumferential wiring was performed to restore the anatomical position of the neck-shaft angle in complex fracture patterns prior to nail insertion. All fractures healed within the expected time period without any complications.

The use of bone grafting at the fracture site in cases of subtrochanteric fracture is controversial.<sup>2, 4, 13</sup> Some

authors have suggested that a sizable fracture gap or bony defect is a significant factor in nonunion and implant failure and have recommended bone grafting in the defect site of medial femoral cortex.<sup>4, 13</sup> According to our previous experience, large fracture gaps or bony defects can result in a prolonged union process and protective course. In the current series, bone grafting was used in 4 cases, and all fractures healed uneventfully.

Femoral head penetration and cut-out of the helical blade have not been observed during the follow-up of our patients. This improved outcome maybe attribute to several factors. First, PFNA-long is a long nail, which can provide better stability. Second, the helical blade is inserted into the femoral neck in order to reduce bone loss. Moreover, biomechanical tests have demonstrated a significantly higher cut-out resistance compared with commonly used screw systems.<sup>14, 15, 25</sup> Third, the bone union rate is high.

In conclusion, the results of this study have showed that PFNA-long is effective in the treatment of subtrochanteric femoral fracture. The limitations of this study are its retrospective and nonrandomized features, small sample size, and relatively short follow-up time. A longer follow-up period and further study with adequate samples are needed.

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(Received February 1, 2009)

Edited by LIU Jun-lan